Dedicated Systems

Small Telescopes in the Era of Big Science

by

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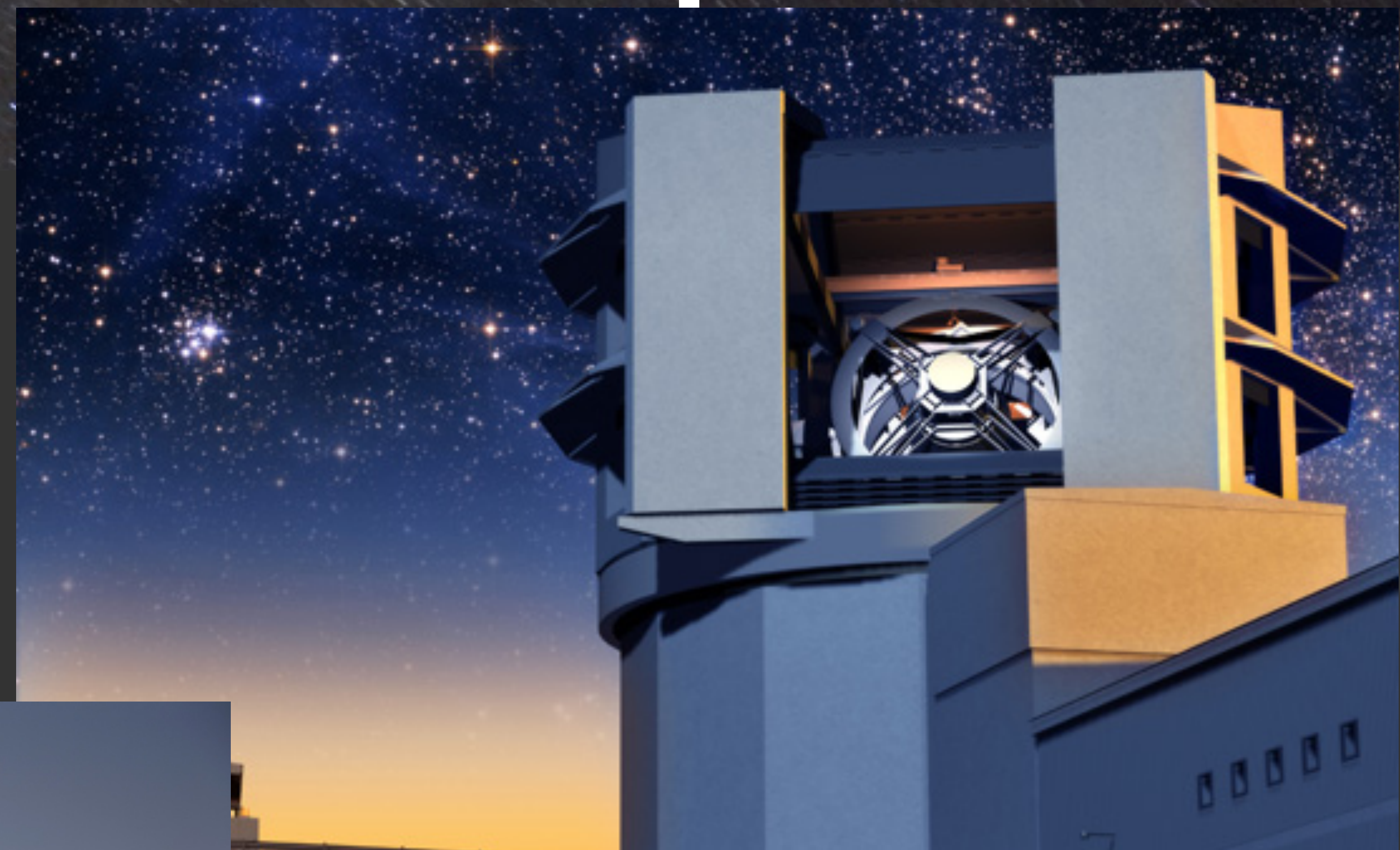
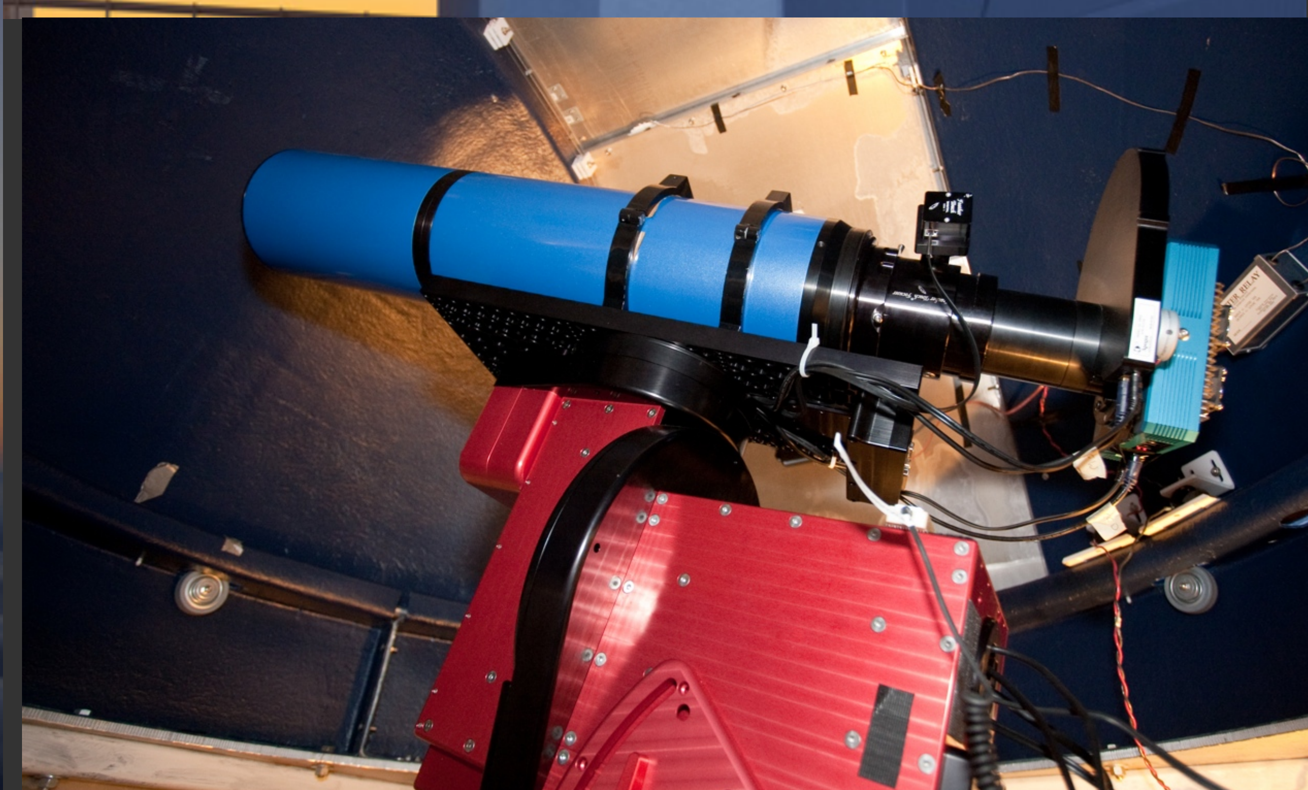
Why Small Telescopes?

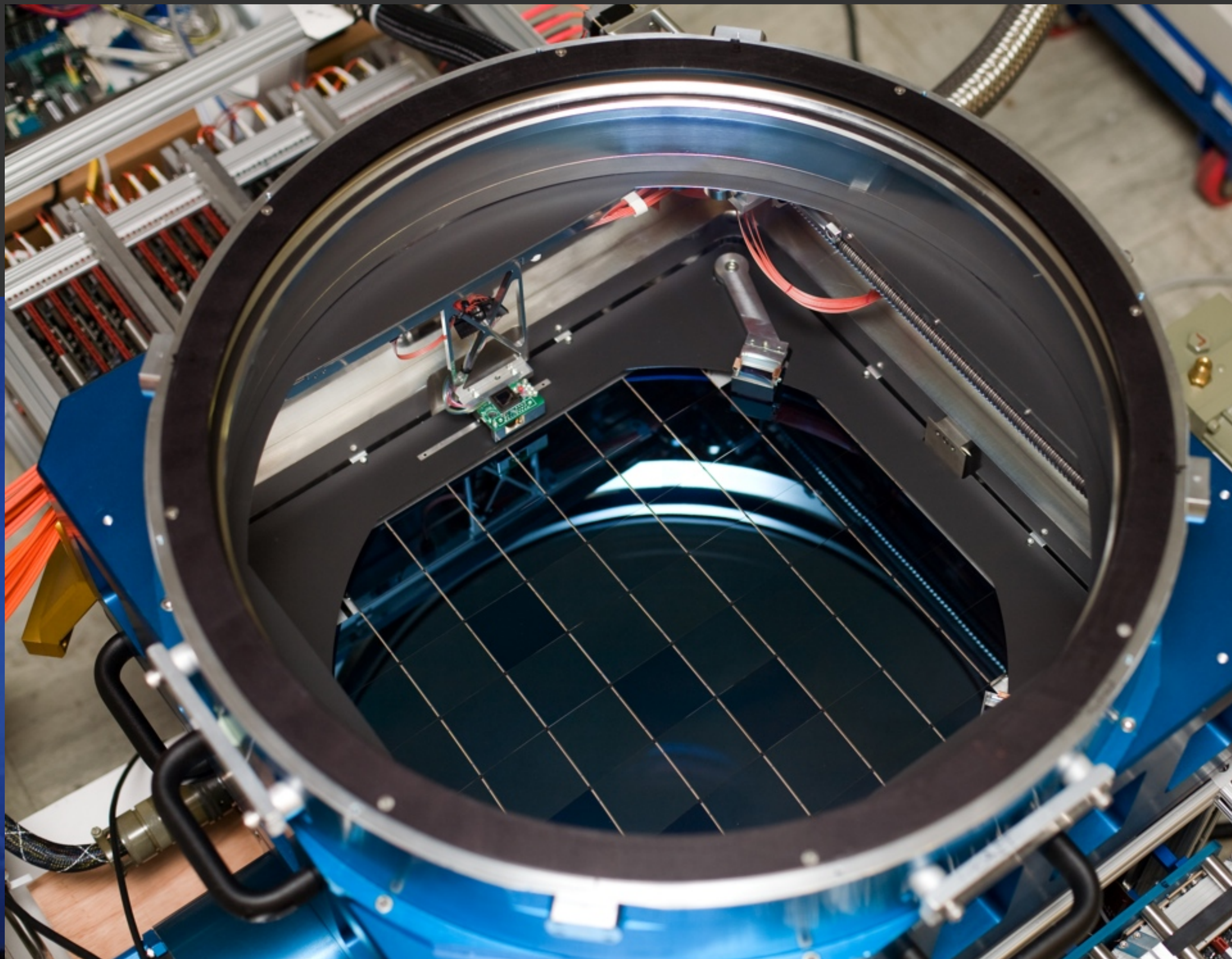
- What role will small telescopes play in the era of large survey projects?





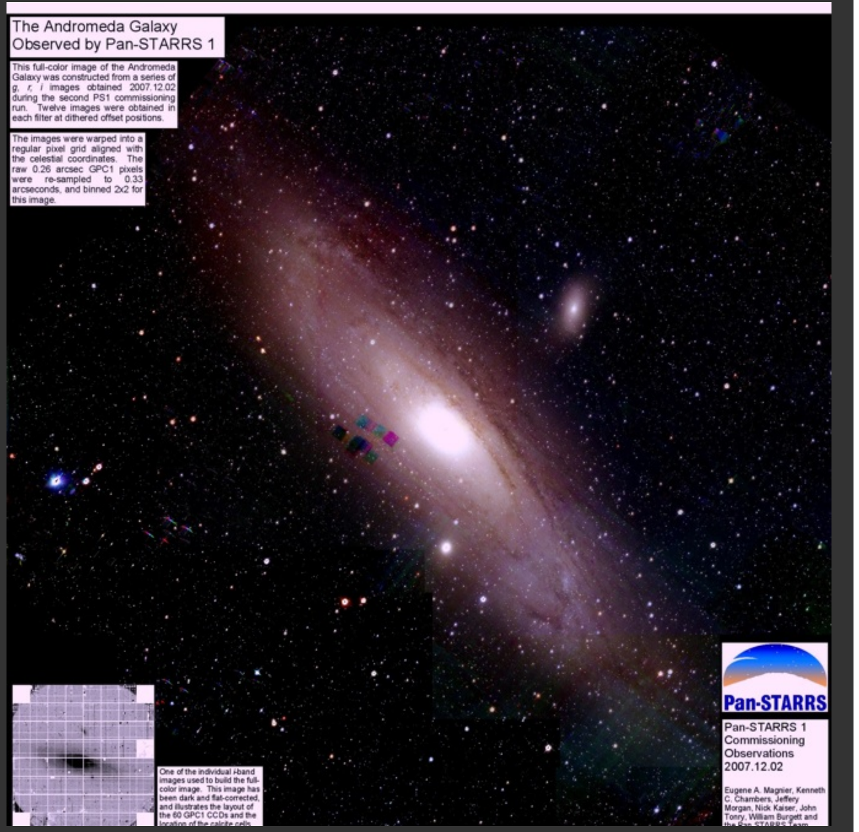
Pan-STARRS

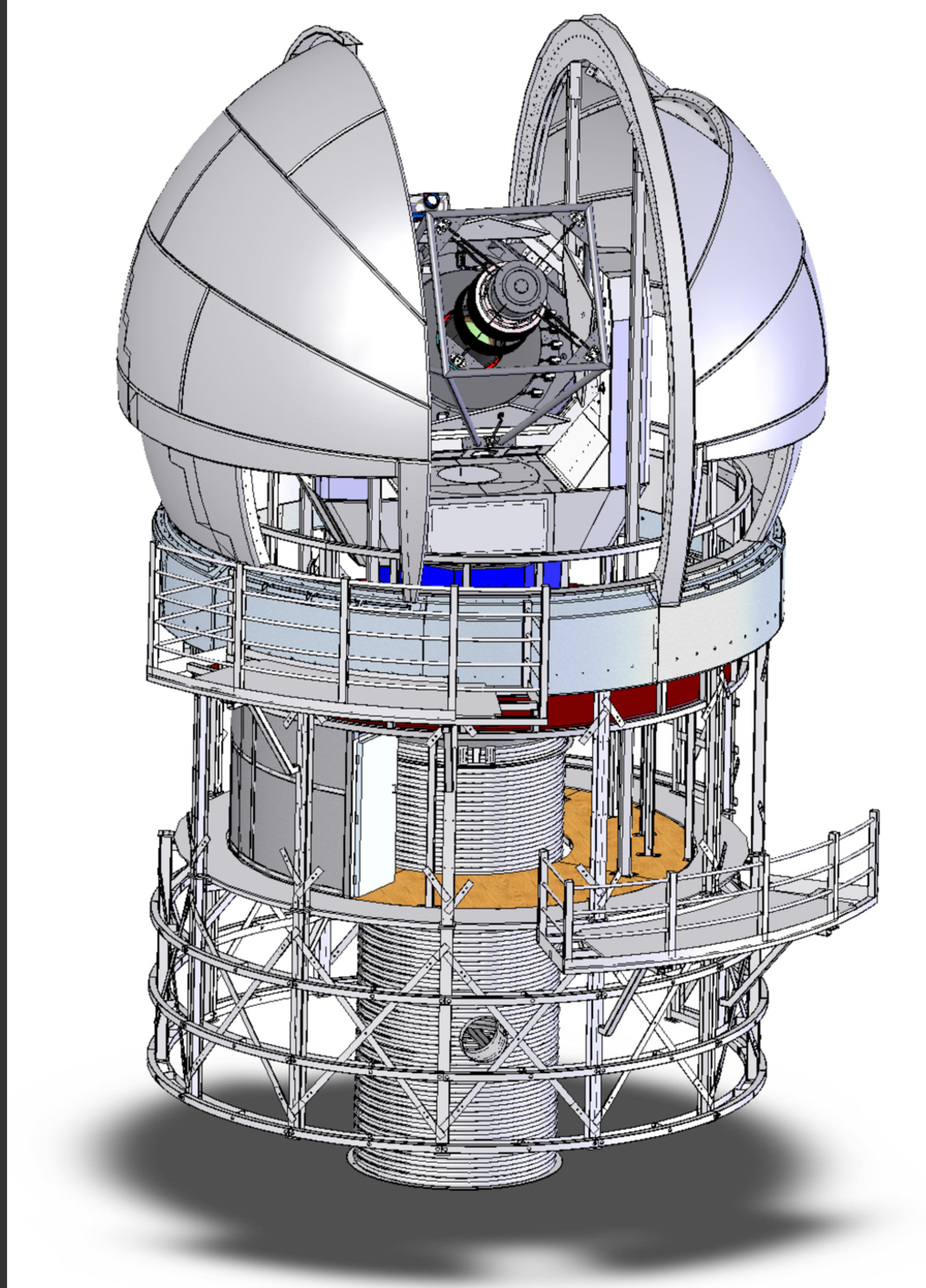
- PS1
  - 1.8 meter telescope on Haleakala, Maui
- PS2 is currently being built



Pan-STARRS

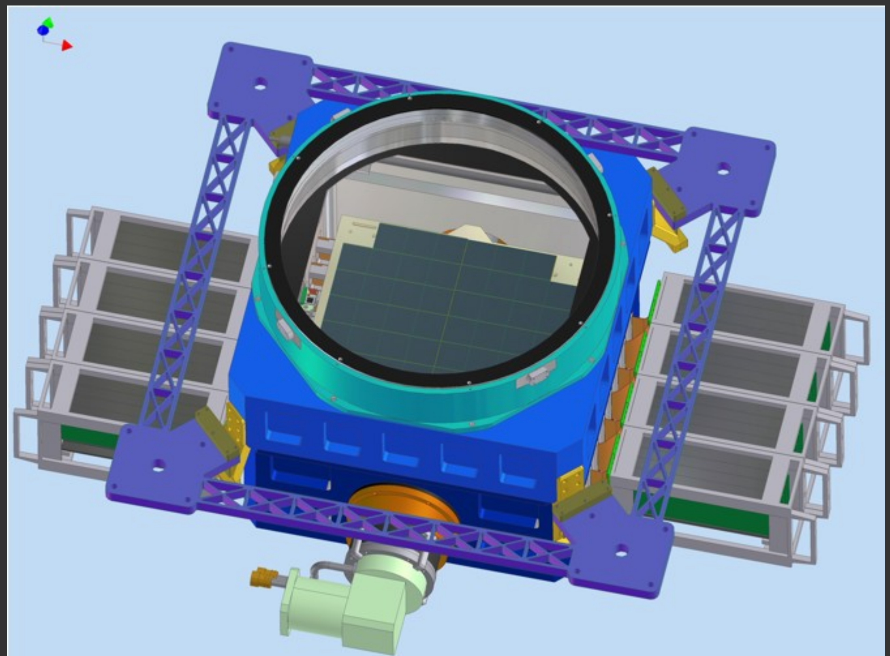
- PS1
  - 1.8 meter telescope on Haleakala, Maui
  - 1.4 Gigapixel camera
  - 3.2 degree diameter FOV
  - 3 Terabytes per night
    - a “data tsunami”





Pan-STARRS

- OTIS: Observatory, Telescope, Instrument, Software
  - custom control system for remote observing
- IPP: Image Processing Pipeline
  - custom data reduction & analysis
  - handles 3 TB per night
- PSPS: Published Science Products System
  - database that makes catalogs available to complex queries



Pan-STARRS

- All of this makes Pan-STARRS a very powerful system
- Has large staff and large budget
- How can a small project compete?

Science with Pan-STARRS

The design of Pan-STARRS is heavily weighted towards its primary purpose, which is to detect potentially hazardous objects in the Solar System. But the wide-field, repetitive nature of the Pan-STARRS observations makes them ideal for a host of other astronomical purposes, ranging from Solar System astronomy to cosmology.

YOUNG STELLAR OBJECTS

The youthful exuberance of young stars makes them among the most variable of all astronomical phenomena, and essentially all known young stars show photometric variability at some level. Brightness and color changes arise from rotation, instinsic luminosity variations, orbiting dust clouds, accretion processes, eruptions, and magnetic and binary effects. THe ability of Pan-STARRS to search the whole of the galactic plane for variable sources will provide a vast resource for the study of star formation.

- **PS1Director**
  - Ken Chambers
- **Maui Staff**
  - Bob Calder, PS1 Operations Manager
  - Cindy Geibink, IT Specialist
  - Tommy Goggia, Pan-STARRS Project Observer
  - Hayden Huntley, PS1SC Software Engineer
  - Tom Melsheimer, Technical Specialist
  - Stephen Mohr, PS1SC Software Engineer
  - Natalia Primak, PS1 Observer
  - Angela Schultz, PS1 Observer
  - Jacob Thiel, PS1 Observer
  - Shannon Waters, PS1 Observer
- **Manoa Staff**
  - Serge Chastel, PS1SC Software Engineer
  - Heather Fleweling, PS1SC Postdoctoral Researcher
  - Roy Henderson, PS1SC Software Engineer
  - Chris Kaukali, Fiscal Officer
  - Eugene Magnier, Image Processing Pipeline (IPP) Leader
  - Paul Price, PS1SC Postdoctoral Researcher
  - Bill Sweeney, PS1SC Software Engineer
  - Chris Waters, PS1SC Postdoctoral Researcher
- **Pan-STARRS Project Development and Support Staff**
  - Greg Ching, Camera Group Technician
  - Larry Denneau, Pan-STARRS Project Software Engineer and MOPS Lead
  - Greg Gates, Pan-STARRS Project Telescope Engineer
  - Jim Heasley, Pan-STARRS Project PSPS Leader
  - Conrad Holmberg, Pan-STARRS Project PSPS Software Engineer
  - Sidik Isani, Camera Group Software Engineer
  - Aaron Lee, Camera Group Electrical Engineer
  - Jeff Morgan, Pan-STARRS Project Senior Telescope Engineer
  - Peter Onaka, Camera Group Leader
  - Craig Rai, Camera Group Software Engineer
  - Lou Robertson, Camera Group Machinist
  - Erik Small, Pan-STARRS Project Software Engineer
  - John Tonry, Gigapixel Camera
  - Robin Uyeshirio, Camera Group Electrical Engineer

Problem 1: Slow

- Covering the whole sky, even with a specially built wide field telescope is slow
  - “The 3pi Steradian Survey covers the entire sky north of declination -30 with a total of 60 epochs, twelve each in 5 filters.”
  - PS1 Mission lasts about 3-4 years

- A dedicated telescope can visit important fields much more often
  - PS1 does for key projects (i.e. M31 & 10 medium deep fields)

Problem 2: Yearly Coverage

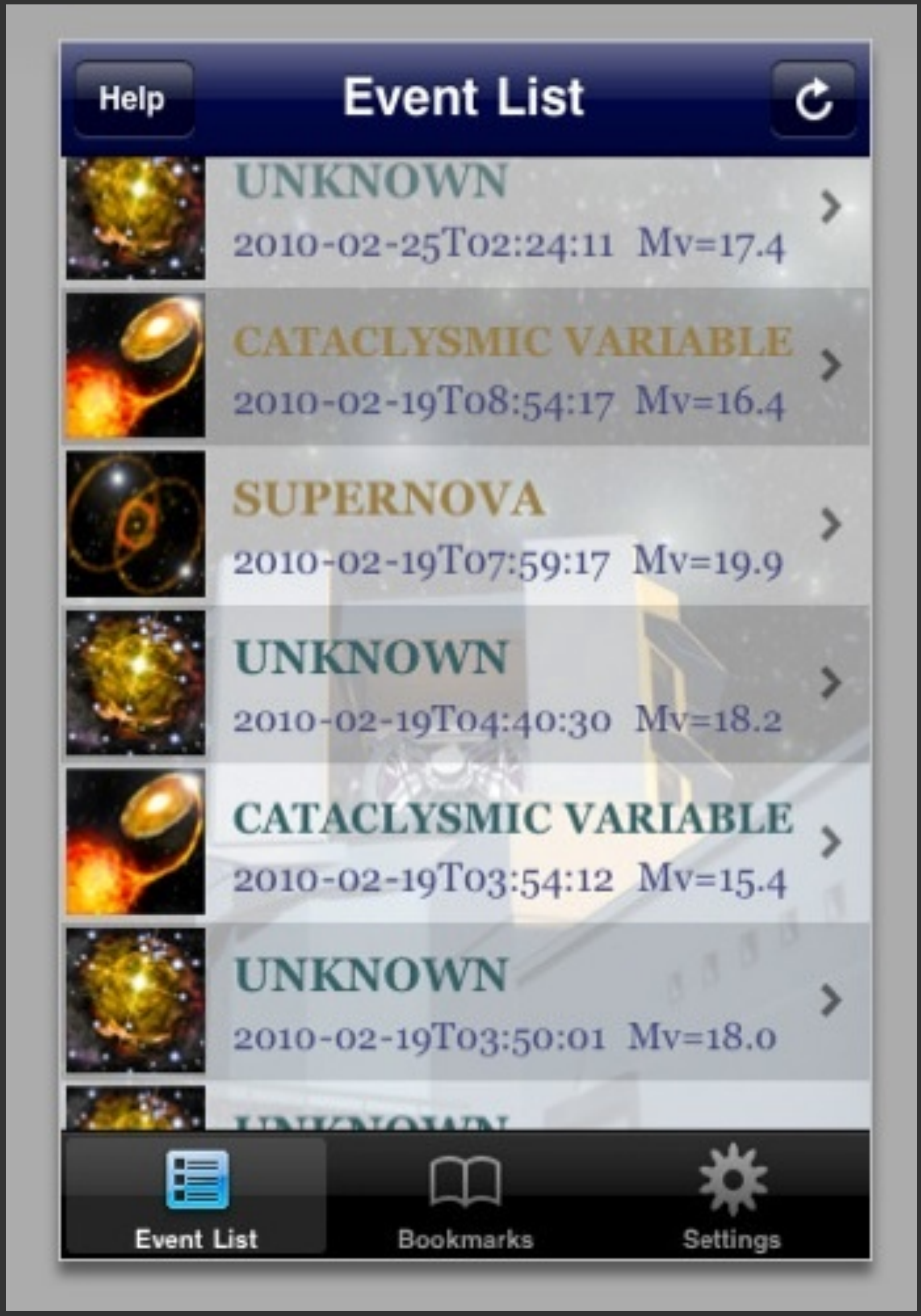
- Automatic surveys of large areas are usually scheduled to observe area which are high in the sky at the moment
  - Maximizes image quality
  - Reduces seasonal coverage

  - Example 1: Galactic Center from Mauna Kea
    - At end of twilight is setting at end of August / start of September
    - Is observable in to October at beginning of night

  - Example 2: Orion from Mauna Kea
    - At end of twilight is setting at end of February
    - Is Observable in to mid-April at beginning of night

Small Telescopes as Follow Up Engines

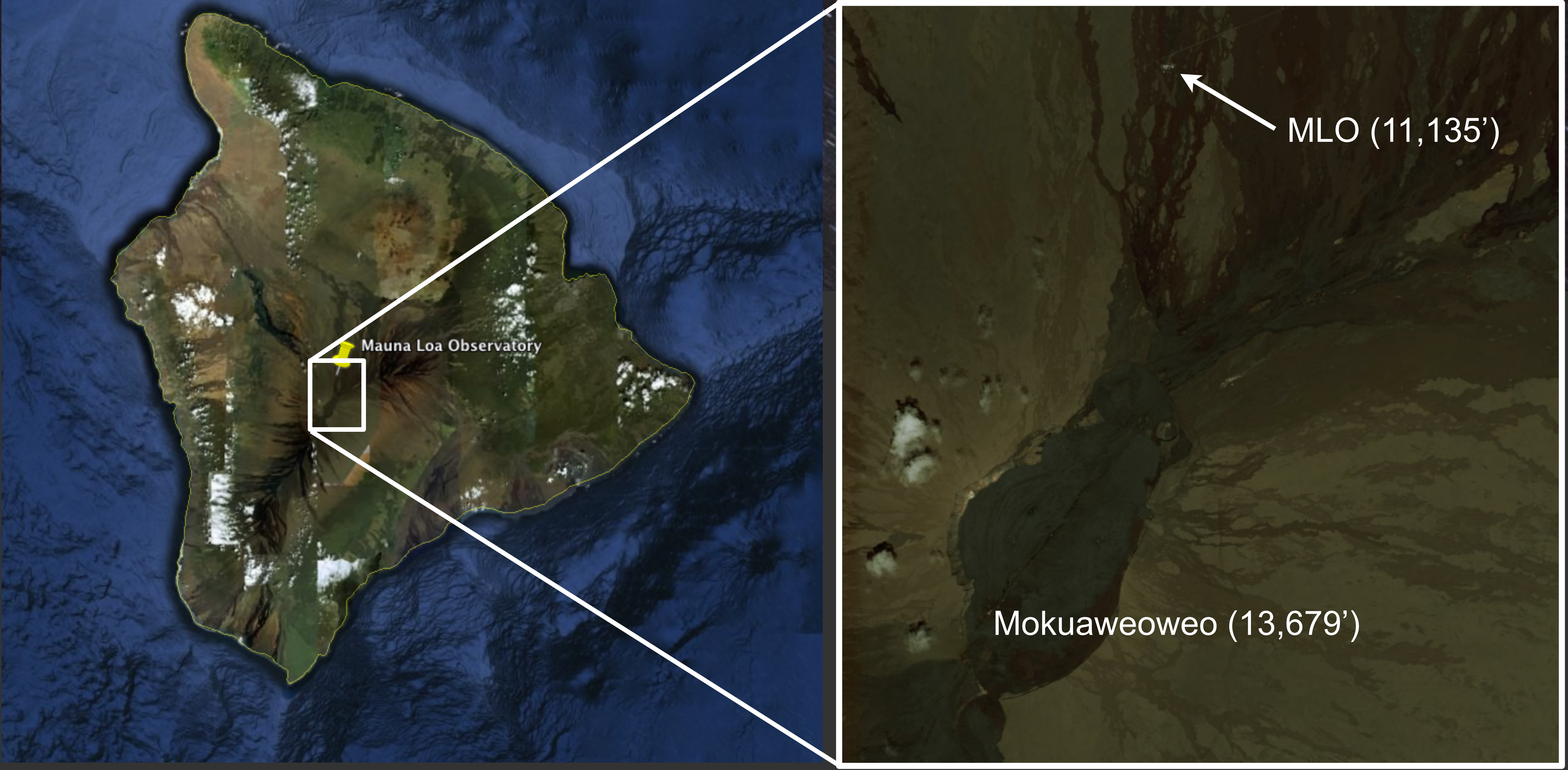
- Large surveys are usually discovery engines
- i.e. LSST will generate tens of thousands of alerts per night
- Many events will be unclassified and will be lost if not observed
- Too many events for existing large telescopes



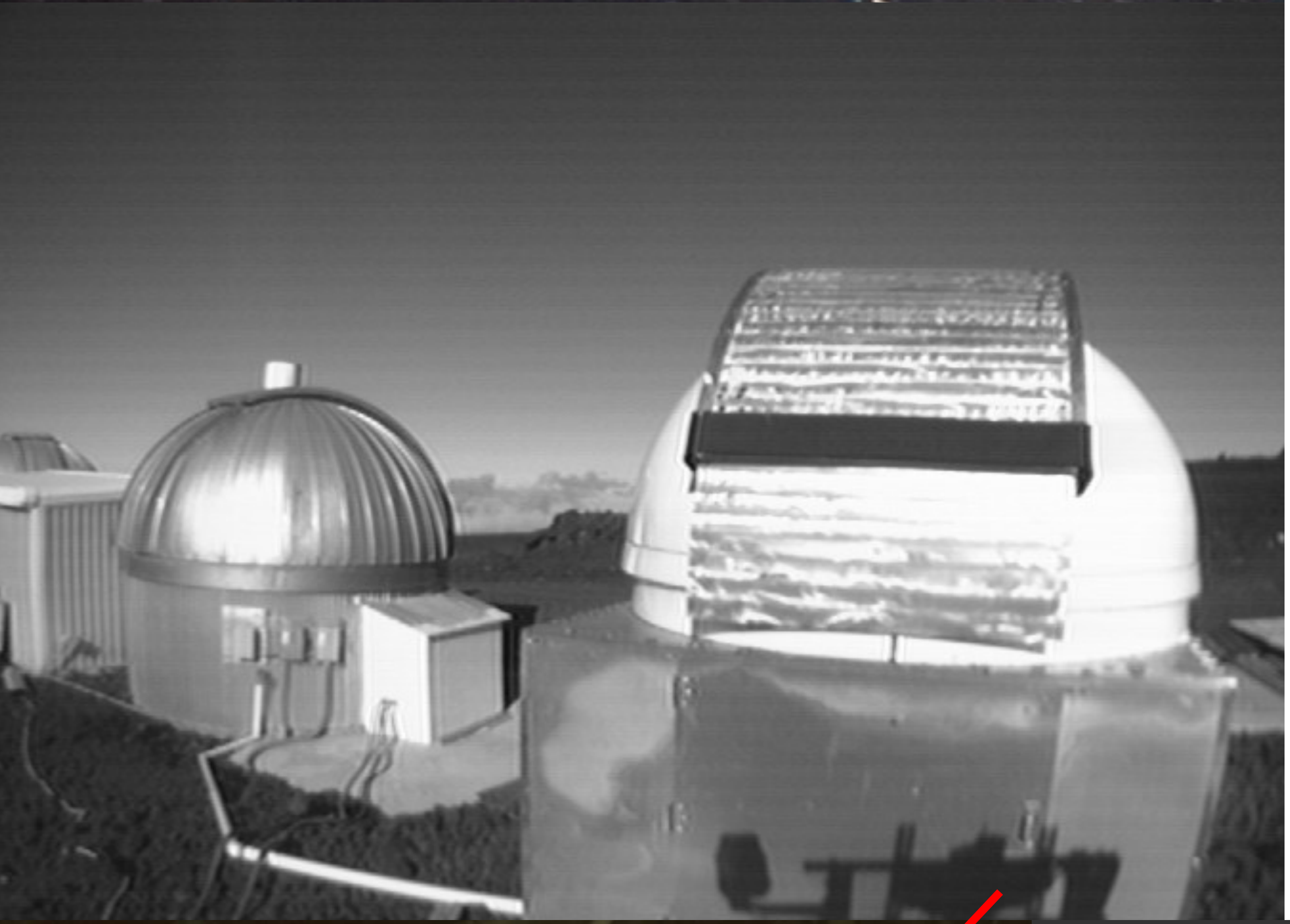
VYSOS Project Goals

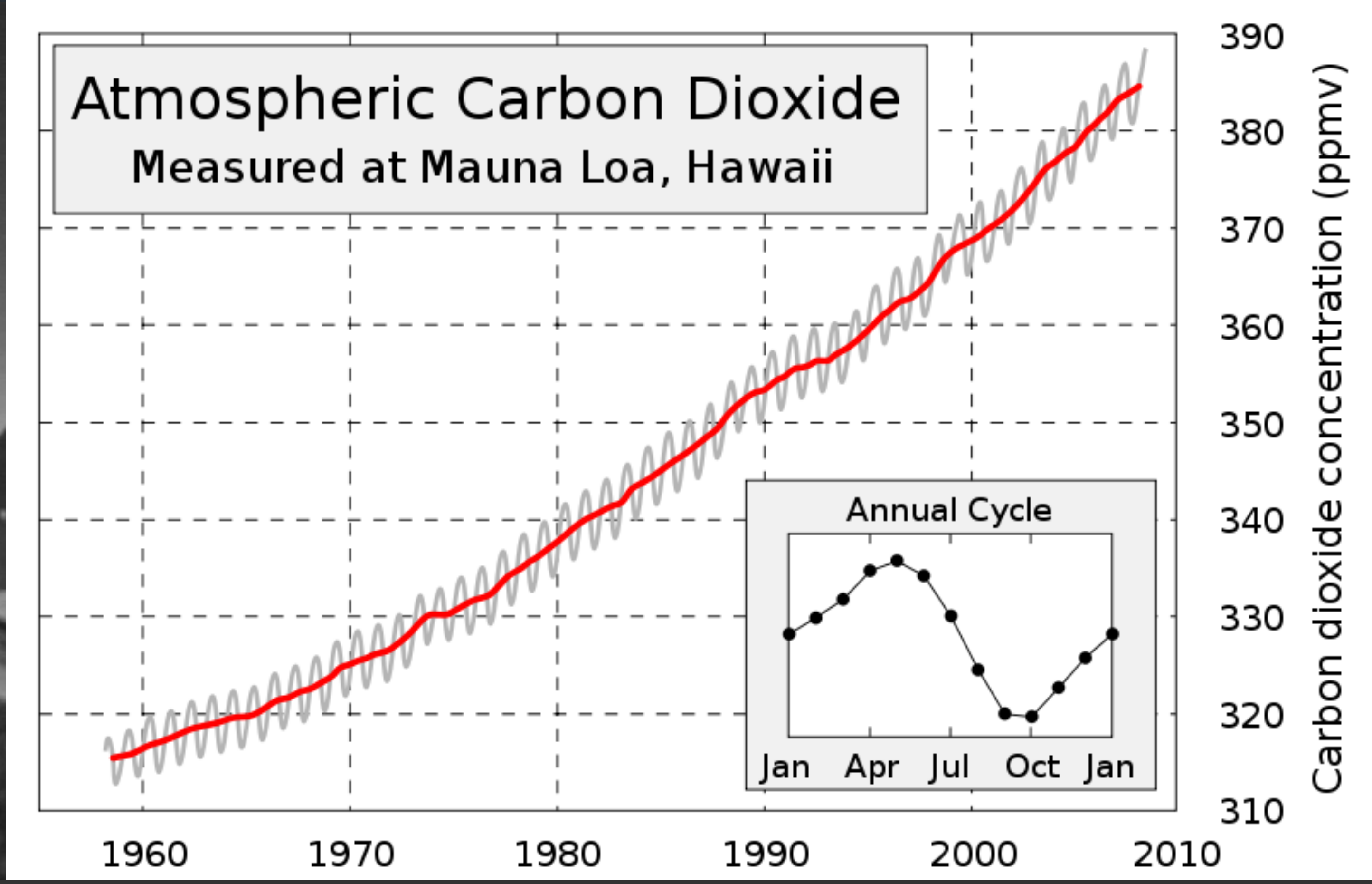
- Generate a photometric record of all nearby star forming regions
  - identify young stars through their variability
  - find and examine outbursts such as FUor and EXor events
    - like McNeil's Nebula
  - find young eclipsing binaries
    - direct measurement of pre-main sequence stellar properties
- VYSOS is primarily a "discovery engine"
  - can trigger proposals for follow up on large telescopes
  - also serves as its own "follow up engine"

- Build and operate two automated telescopes

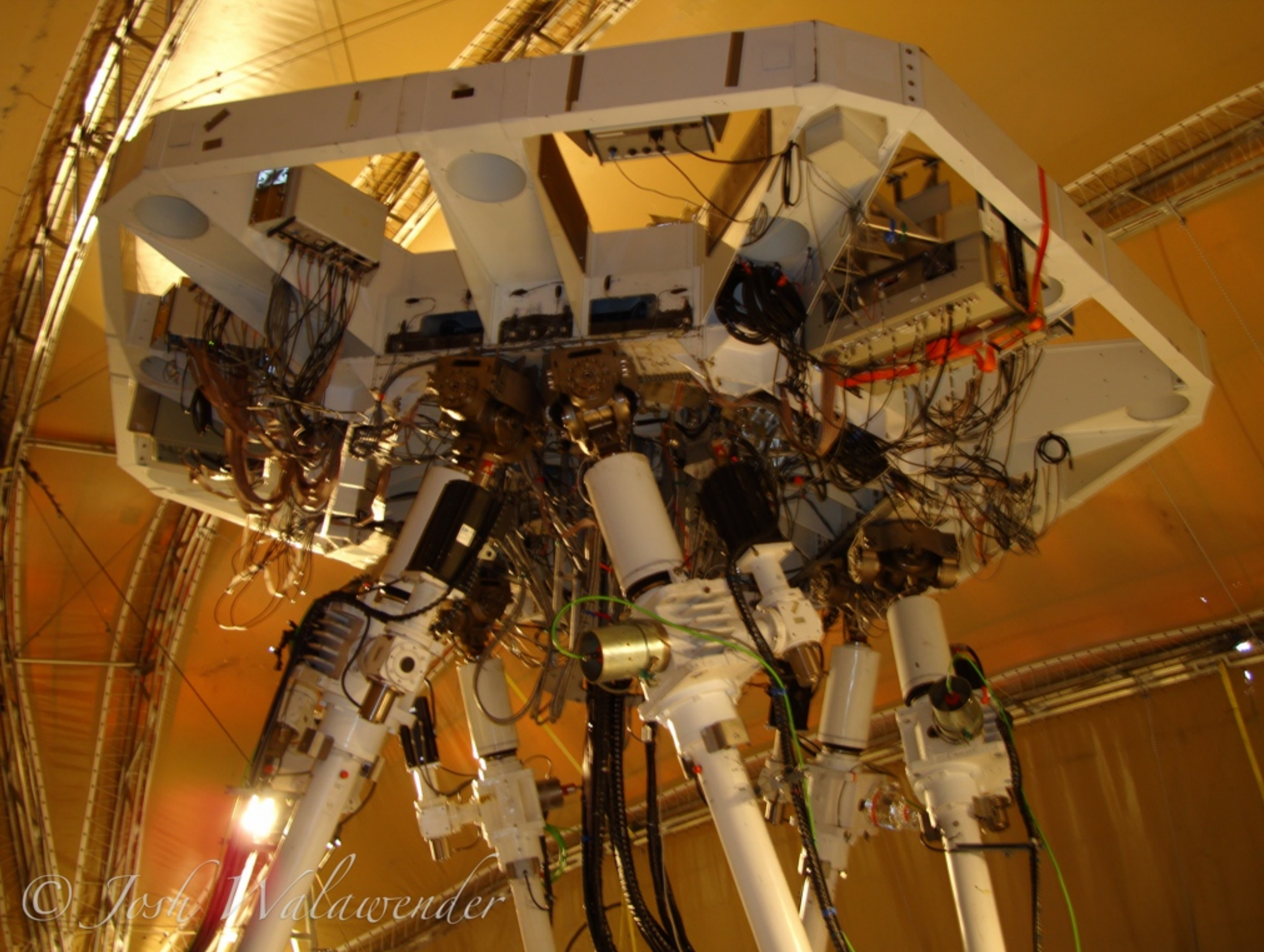


- Located on the slopes of Mauna Loa on the Big Island
  - Earth’s largest shield volcano
  - second tallest mountain on Earth (after Mauna Kea, 117’ taller)

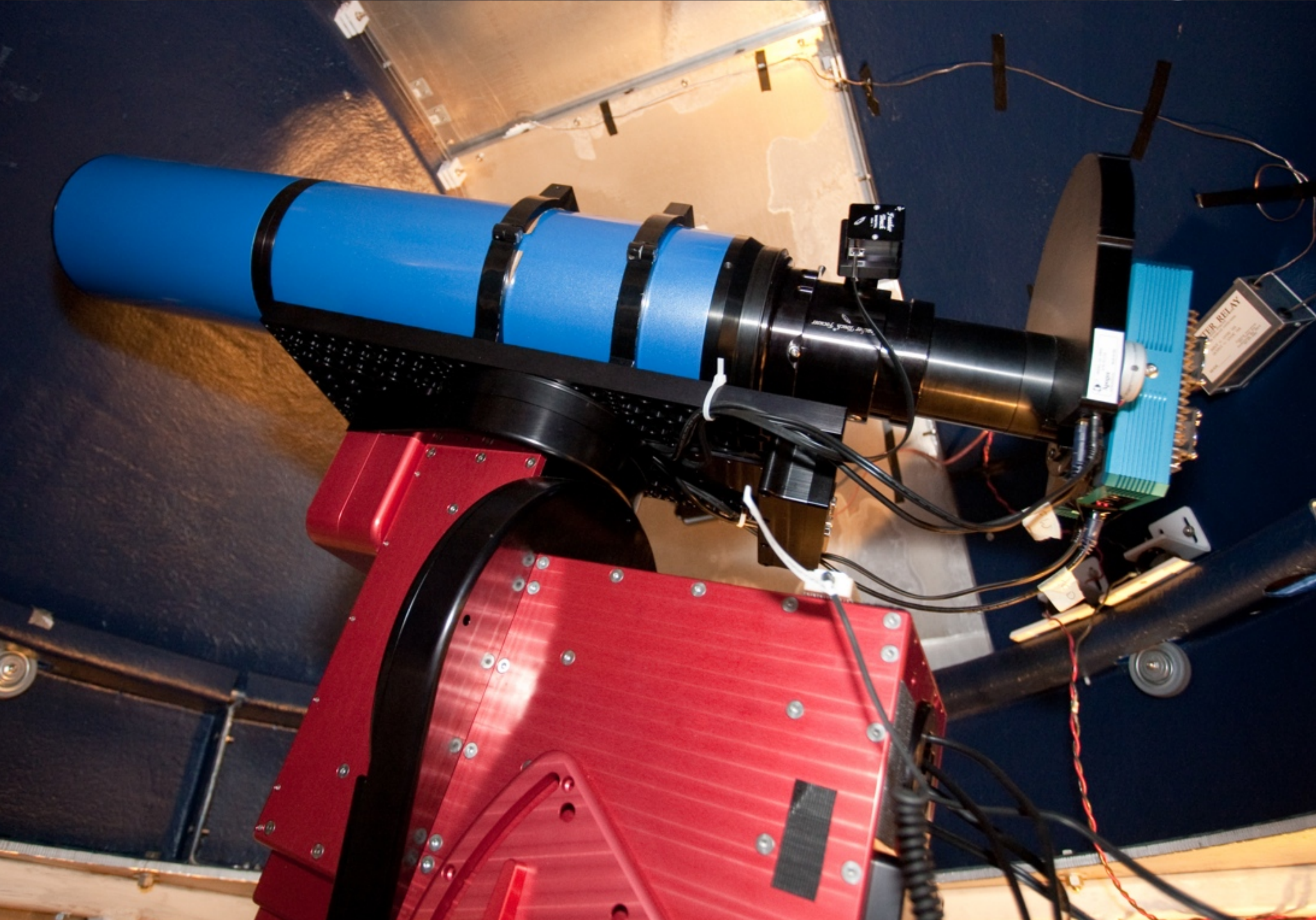




- NOAA Mauna Loa Atmospheric Observatory (established 1956)
  – original site for Keeling Curve data
- VYSOS occupies two domes
  – one older dome
  – one new small dome



- NOAA Mauna Loa Atmospheric Observatory
  - AMIBA
  - MLO Solar



VYSOS-5

135mm aperture, f/5.4
2.9 degree field of view

Limiting magnitude of 17.7 in r’
(5 sigma, in 3x100 second exposures)

Primary Mission:
Scan an 8.5 degree wide strip along the galactic plane to search for variable phenomena.

VYSOS-20

20 inch (500mm) aperture, f/8.1
0.5 degree (30 arcminute) field of view

Limiting magnitude of 20.5 in r’
(5 sigma, in 3x100 second exposures)

Primary Mission:
Image known star forming regions to monitor the brightness fluctuations of young stars.